A Quantity Estimated Method to Measure the Flow of Nodes in Hub and Spoke Network -Evidence from Courier Service Network

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Abstract

Measuring the flow of any node to all other nodes in a hub and spoke network is important for tactical, operational, and strategic decision-making. To measure the flow of any node to all the other nodes, data on both the quantity transported and the travel time taken from the node to all the other nodes in the network is required. In the literature, the flow of any node to all the other nodes in a hub and spoke network has been measured using the known data on quantity transported and travel time taken. At times, getting reliable data on the quantity transported between nodes is difficult due to many reasons, such as confidentiality and lack of proper recording of data. Therefore, the quantity transported between nodes must be estimated. The objective of this study is to develop a quantity-estimated method to measure the flow of any node to all the other nodes in a hub and spoke freight network. As the first step, the distances of all nodes to their respective nearest main trip generators were found. Nodes could represent warehouses, and the trip generators could represent cities, villages, industrial zones etc. Then the lowest and highest distances were figured out among the entire distances range. Using the lowest, highest and respective distance for each node, a criticality factor was assigned to each node. The criticality factors were ordered from the highest to the lowest. Nodes were categorized into three sections such as highest, medium and lowest. Each category was set to have an equal number of nodes. Then the criticality factor of the hub node was multiplied by the capacity of the vehicle to estimate the quantity transported from the hub node to all the other nodes respectively. This resulted in the estimated quantity of goods received by each spoke node from the hub node. Using the estimated quantity of goods received by each spoke node from the hub node, each node category (based on the criticality factor) was given weights. Then the quantity transported between any pair of nodes was estimated based on the weights of the respective node category, vehicle capacity and the number of nodes in respective node categories. Using this method, the quantity transported from any node to all the other nodes was calculated. This calculated value was divided by the estimated summated travel time from the node to all the other nodes in the network. The travel time data was derived from Google Maps. This ratio of the estimated quantity transported from a particular node to all the other nodes and the respective travel time from the node to all the other nodes resulted in the estimated flow of the node in the hub and spoke network. This method of measuring the flow of nodes was applied to a local courier service network in Sri Lanka. This courier service had 27 spoke warehouses around the island and a hub warehouse in the Capital, Colombo. This method was applied to the highway network and expressway network at both peak and off-peak conditions. The results revealed that warehouses that were in Vavuniya and Jaffna had the lowest flow, with 0.8489 kg/h and 0.294 kg/h. These warehouses could be relocated or consolidated to minimize the total expenditure. The highest flows were obtained at Biyagama and Katunayake warehouses, with flows of 1.4052 kg/h and 1.4191 kg/h, respectively. These warehouses could be occupied with more material

handling equipment. The results yielded many recommendations for lowering the waiting time at warehouses, using the expressways etc. This research contributed to the domain of hub and spoke network by developing a quantity-estimated method of measuring the flow of nodes.

Keywords: *Hub and Spoke Network, Node Flow, Courier Service, Quantity Estimated*

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